Induction and Hard Drives

To help his physics students understand the concept of electromagnetic (EM) induction, Brian Lamore, physics teacher at The Chinquapin School in Highlands, TX, devised an experiment involving strong neodymium (Nd) magnets, #28 magnet wire, and the Vernier Instrumentation Amplifier (INA-BTA, $59).

To connect the concept with a relevant application, Brian used older hard drives and floppy disks as examples, since they operate on the principle of EM induction—where a change in magnetic flux induces an emf in a conductor. When the reading head with its small coil moves over the magnetic surface of the disk, small signals are interpreted by the coil as digital 1's and 0's.

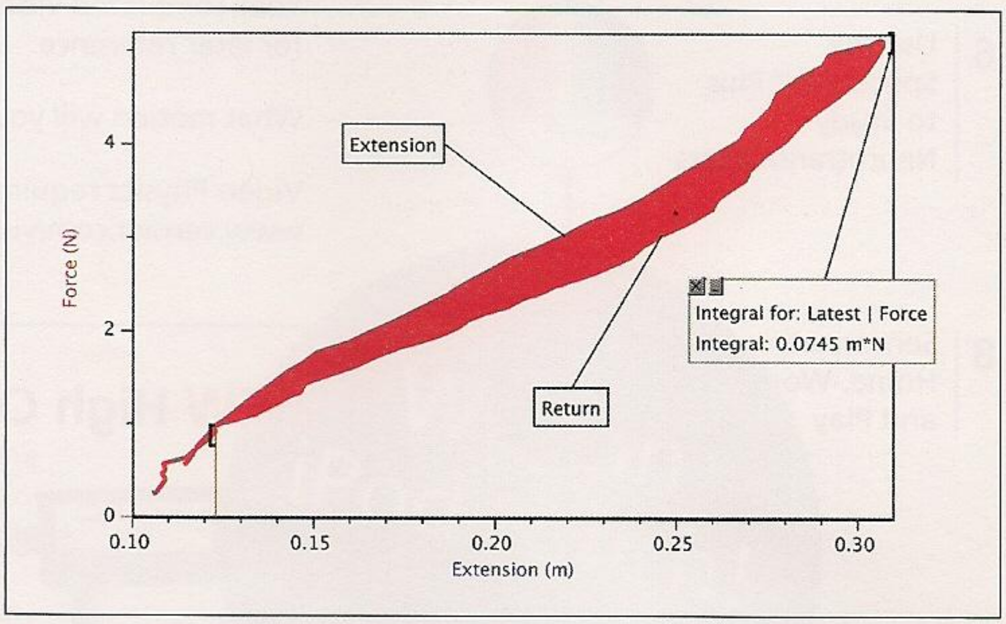
In class, Brian wound the wire 50 times around his index finger, sanded the wire's ends, and inserted them into the Amplifier. He showed students the results when one magnet passed the coil, when five of all the same polarity passed, and when three of one polarity and two of the other passed. Each polarity reads differently, thus signaling digital 1's and 0's.

Brian even set the coil in harmonic motion and ran a magnet past it to produce a damped sinusoidal waveform. "This relatively simple experiment has great potential for investigations into not only electromagnetism, but also electronics and calculus," Brian said. Brian used Logger *Pro* to collect and graph all data.

Elastic Hysteresis of a Rubber Band

Professor Richard G. Born, from Northern Illinois University, devised an experiment to study hysteresis, the delay of time between a force being placed upon a system and the exhibited reaction. Born placed a 7 inch rubber band on a Vernier Dual-Range Force Sensor (DFS-BTA, $109), with a Motion Detector (MD-BTD, $79) placed on the floor below the rubber band. He extended the rubber band downward, pulling it with his hand, and released it upward, loading and unloading the rubber band. The Motion Detector recorded the position of his hand. During the five-second trial, Born sampled the extension distance and the magnitude of the force applied to the sensor.

To analyze the results, Born compared the measured force in Newtons, with the extension of the rubber band in meters. Students could see that the rubber band did not obey Hooke's law, resulting in a non-linear relationship. Also, there was more force applied during the loading than the unloading of the rubber band, indicating that the system lost energy. This is represented in the space between the loading and unloading curve on the graph. Using the Integral function of Logger *Pro*, it was possible to determine the area between the loading and unloading sections of the graph, and to quantify the energy loss in Joules (N•m).



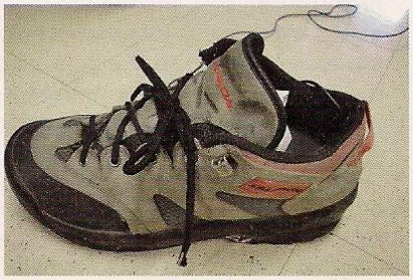
Net work done on rubber band during extension and return

Shoe Cushioning

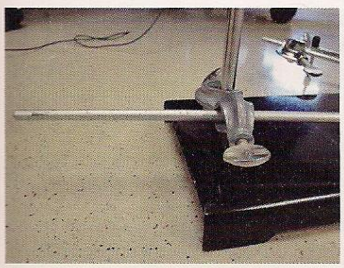
Here is an activity that some of your students may find interesting. The goal is to test the cushioning for various shoes and boots. We measured the acceleration in a "heel drop" of standardized height.

We used a 25-g Accelerometer (ACC-BTA, $92) attached to a 500 *g* mass, placed inside the shoes. We used the 500 *g* mass that we sell for use with our Vernier Dynamics Carts. This mass works well because it has a hole in it, so it can easily be bolted to the Accelerometer.

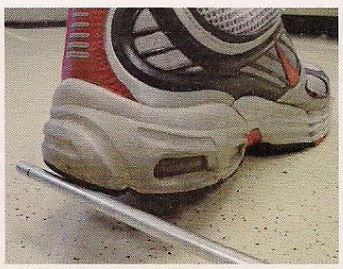
The Accelerometer/mass was placed in the heel of the shoe, and the shoe was packed with recycled paper to keep things in place. We rested the tip of the heel of the shoe on a rod attached to a ring stand to standardize the drop distance. With a Logger *Pro* file set to trigger on an increase in acceleration



Shoe with accelerometer in heel



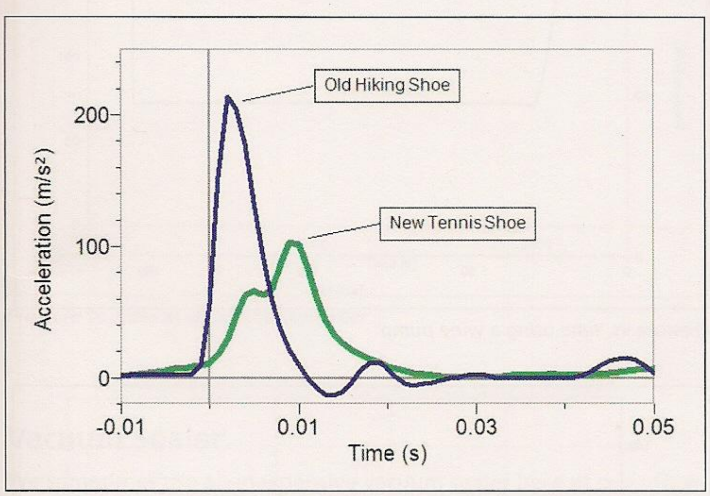
Rod on ring stand used to standardize heel drop



Shoe in position for drop

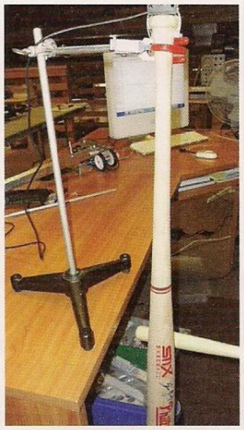
and a very high data-collection rate, we pushed the shoe off the rod with just enough force to release the shoe.

Typical drops are shown below. As you might expect, the peak acceleration varies with the shoe type and shoe condition. The most surprising thing is how large the accelerations are for even a drop of just a couple centimeters.



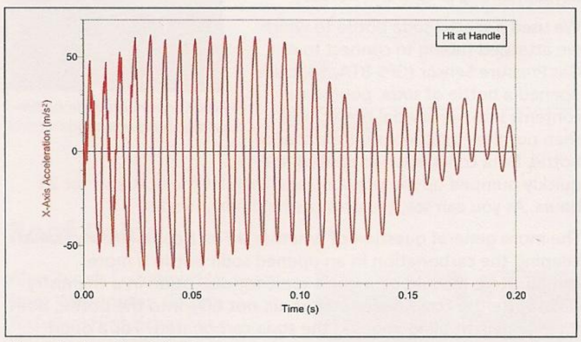
Acceleration data for typical drops

The Sweet Spot on a Baseball Bat

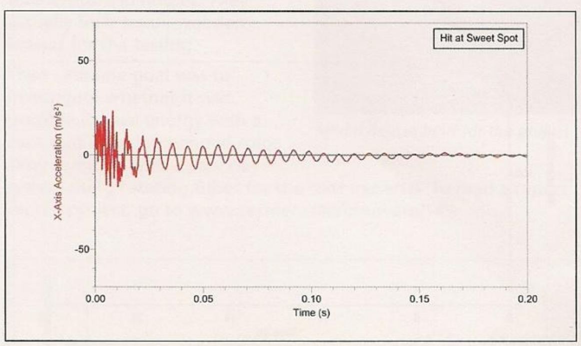


We recently attended the American Association for Engineering Education meeting in Louisville, KY. While there, we had a free afternoon, so we went to the Louisville Slugger Bat Museum. In the museum, they had an exhibit where they asked you to hold a baseball bat vertically, suspended by the knob, and then to tap it with another baseball bat at different spots along the bat. The idea was to see if you could find the "sweet spot," which is the center of percussion—where the rebound force of the bat is completely balanced out by the force of the ball. When the bat hits the ball at the sweet spot, the batter will feel very little vibration in the handle from the impact.

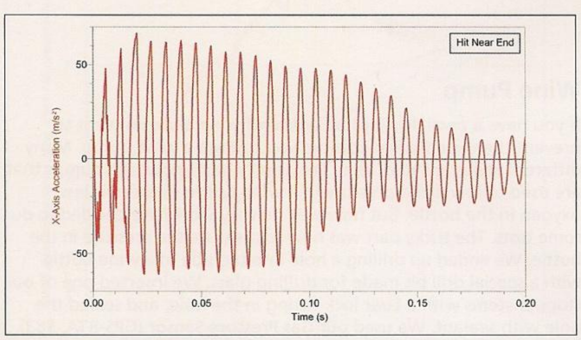
Michele Perrin, a teacher who works with us on projects in the summers, came up with the idea of mounting one of our Low-*g* Accelerometers (LGA-BTA $89), on the knob of the bat and monitoring the vibrations, while we do the tapping. Here are some results:



Hit at the handle of the bat



Hit at the sweet spot of the bat



Hit near the end of the bat

Wine Pump

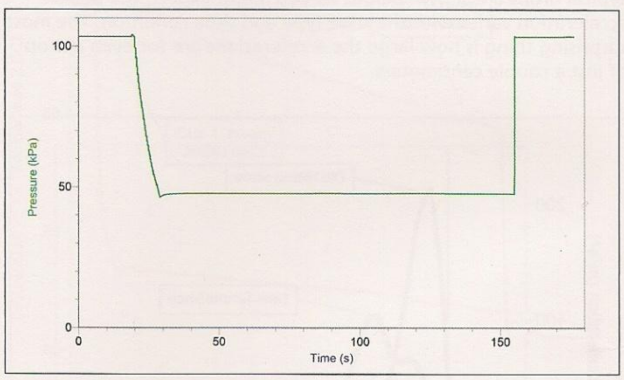
If you have a partially finished bottle of wine and you want to prevent the wine from oxidizing, you can use a wine pump. Many different styles are sold. They are usually hand-powered pumps that are used to lower the pressure in a wine bottle so there is less oxygen in the bottle. But how well do they work? We decided to do some tests. The tricky part was how to measure the pressure in the bottle. We ended up drilling a hole into the side of a wine bottle with a special drill bit made for drilling glass. We inserted one of our stopper stems with a Luer lock fitting in the hole, and sealed the hole with sealant. We used our Gas Pressure Sensor (GPS-BTA, $83) to measure the pressure.

We tried two different models of wine pumps. Two sample graphs are shown below.

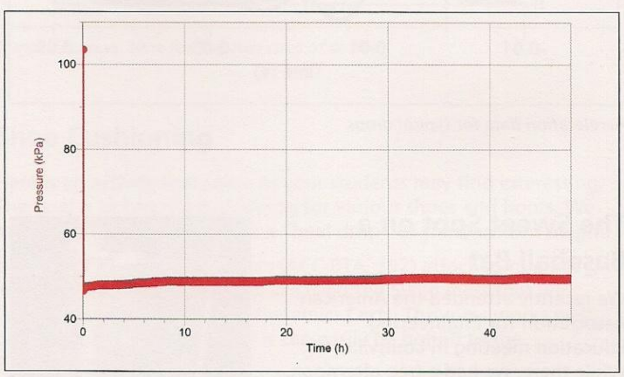
The top graph shows one model of wine pump. Note that the pressure is quickly reduced to a little less than a half atmosphere. It is difficult to get much lower pressure with these pumps.

We were curious if the pumps really held the pressure. The second graph is a two-day run with a different model of pump. Note that the pressure again is just a little less than half an atmosphere.

Wine pumps



Pressure vs. time using a wine pump



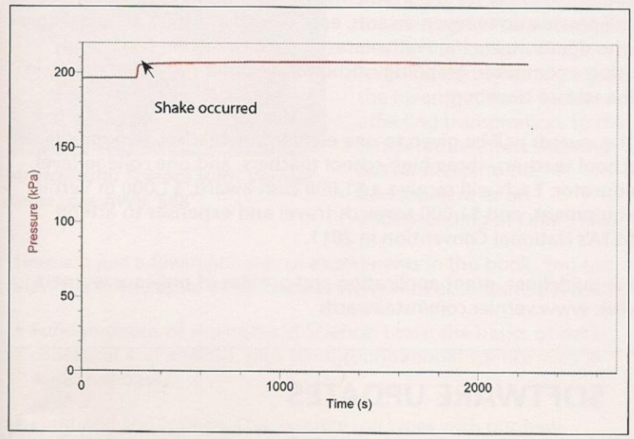
Bottle pressure over two days

Pressure in a Dropped Soda Can

In the book *What Einstein Told His Barber*, by Robert L. Wolke, there is a section discussing champagne, soda, and pressure. He says, "If I said that shaking a bottle of champagne, beer, or pop raises the gas pressure inside, 99 out of 100 people, even chemists and physicists, would agree. But it's not true." (page 232)

We were intrigued by this challenge. A quick search on the internet will lead you to many vigorous arguments both supporting and denying the pressure change on shaking. We did not have a quick way to measure the pressure inside a soda can, but we decided to use our special wine bottle. Our results are shown in the graph below.

We had a small change in pressure, but note that our situation was a little artificial. We had to fill our wine bottle with soda (actually Diet Pepsi). We let it sit for a couple of hours before we started the experiment, but our system probably did not have enough time to reach equilibrium. This subject could be a good one for student experimentation.



Pressure vs. time as shake the container